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(54) An optical proximity sensor

(57) Light eg IR is transmitted, preferably from one end 14 of an optical fibre 13 and is received, preferably by the end 15 of another optical fibre 16, after reflection from an object 2 to be sensed. The intensity of the received radiation depends on the range of the object and is at a peak at a particular range. Means is provided for detecting this peak and peforming some control function when it occurs at which time it can correctly be assumed, irrespective of the coefficient of reflection of the object, that the range to the object is a predetermined value.

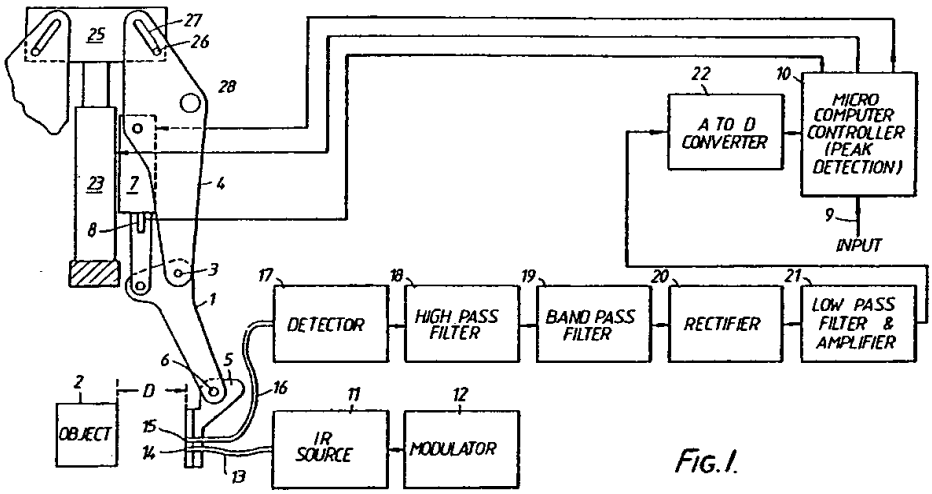

FIG. 1.

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The drawing(s) originally filed was (were) informal and the print here reproduced is taken from a later filed formal copy.

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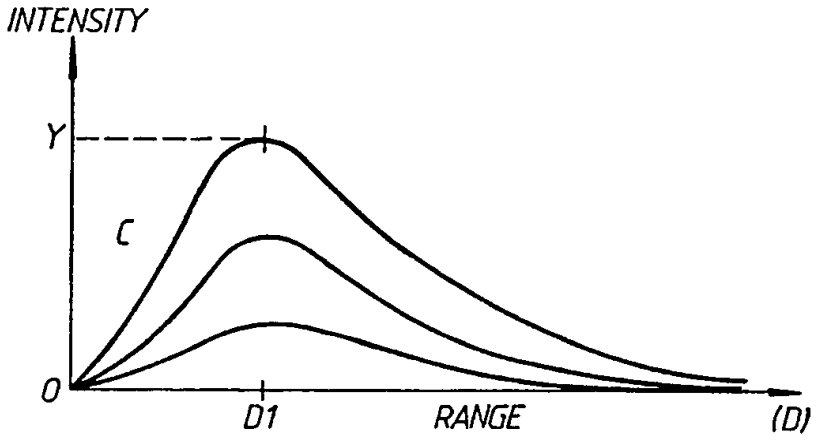

FIG. 2.

SPECIFICATION

An optical sensor

This invention relates to an apparatus of the type comprising an optical sensor having a transmitter and a receiver which are spaced from each other and arranged so that transmitted light is returned to the receiver after reflection from an object to be sensed with an intensity which depends on the range of the object and is at a peak at a particular range.

The term "light" is used in this specification in a generic sense to include any form of electromagnetic radiation and in particular infra-red.

Such known sensors are used to detect the presence of an object which, if present, can be relied upon to be a fixed distance from the sensor. One application for such sensors is for example in a paper feed mechanism to detect feed holes in the paper. A sensor for this purpose is described by G.A. Trudgen in a Paper entitled "Simple Object-Sensor Circuits Give Target-Position Information" published in Electronic Design News, April 19th, 1984. Known sensors of this type can also sometimes be used to measure the range of the object but they are not always suitable or reliable for this purpose since different objects may have different coefficients of reflectivity. Because of this the intensity of the received radiation cannot be used as a true measure of the range of an object having an unknown coefficient of reflectivity. Also of course the intensity of the light source may vary due to ageing and this adds to the unreliability of any such measurement.

The invention arose from the realisation that the aforementioned peak intensity occurs at the same range irrespective of the coefficient of reflectivity of the object to be sensed.

The invention provides, in a sensor of the aforementioned type, a peak detector arranged to receive the output of the receiver and to perform a control function when the output reaches the said peak.

Because the aforementioned peak always occurs at the same fixed range, irrespective of the coefficient of reflectivity, its detection provides a reliable indication of when the object is at that range. The control function performed in response to the detection of the peak can be some mechanical function. Preferably however it serves to set a datum point from which range measurements may accurately be made.

The invention is considered to be particularly applicable for use in a manipulator to detect when a finger or other member of the manipulator is about to touch an object to be manipulated. In such an application of the invention motion of each manipulator finger can be stopped just before it touches the object whereafter the mode of operation of the manipulator can be changed, e.g. by reducing the speed of operation of the fingers as they finally grip the object to be manipulated.

It has previously been mentioned that the detection of the peak can be used to set a datum point from which range measurement may accurately be made. These range measurements can of course be obtained in any known way. For example, if the position of a manipulator finger is being controlled by a stepping motor, the steps of the motor may be counted to give a measurement of the movement effected. Alternatively a potentiometer can be used to give an indication of such movement. Another possibility would be to use the detection of the peak to normalise the input signal, i.e. to amplify or attenuate it so that it has a fixed amplitude at the peak value. The relationship between range and the amplitude of this normalised signal will provide a reliable indication of range independent of coefficient of reflectivity and of intensity of the light source.

One way in which the invention may be performed will now be described by way of example with reference to the accompanying drawings in which:-

Figure 1 is a very schematic illustration of part of a robotic manipulator constructed in accordance with the invention; and

Figure 2 shows the relationship between intensity of signal received by a receiver 15 of Figure 1 and the range D of an object 2.

The illustrated manipulator comprises a number of articulated fingers 1, only one of which is shown in the illustration. These fingers 1 are arranged to grip an object 2. Each finger is pivotted at 3 to a plate 4 and has an end section 5 which can be pivotted at 6 by a mechanism which is not shown because its operation is of no significance in relation to the present invention. Pivotting of the finger 1 is effected by a linear actuator 7 carrying a potentiometer 8 whose output indicates its position at any one time. An operation to grip the object 2 is commenced by applying an input signal on line 9 to a control circuit 10 which, in response, signals the actuator 7 to pivot the finger 1 in a clockwise direction. This moves the finger section 5 relatively rapidly towards the object 2.

An infra-red source 11 is modulated by a circuit 12 to produce infra-red pulses which are transmitted along a fibre 13 to its end 14 which behaves as an emitter directing radiation in a diverging beam towards the object 2. The infra-red radiation is returned, after reflection from the object, to an end 15 of a fibre 16, which end acts as a receiver having directional characteristics similar to the fibre end 14. The intensity of radiation received at 15 is related to the range D of the object 2. This relationship for three different types of object surface is shown by the curves of Figure 2; from which it is to be noted that the maxima all occur at approximately the same range value D1. As the finger section 5 moves towards the object the light pulses received are detected at 17 and pass through a high pass filter 18 to remove effects from ambient lighting driven by the usual 50Hz mains supply. The output of the filter 18 is passed through a bandpass filter 19 tuned to the frequency of the modulator 12. The output of the filter 19 is rectified at 20 and then smoothed and amplified at 21 before being converted to digital form at 22.

The controller 10 detects when the rate of change of the signal from 22 becomes 0, i.e. the peak of one of the curves shown on Figure 2. At this time it can reliably be assumed that the range is at the value D1. The controller then notes the setting of the potentiometer 8 and measures a pre-set change in the setting equivalent to a further movement of the finger sec-

tion 5 by an amount just less than D1. The finger section 5 is then immediately adjacent the object 2. This process is also carried out for the other fingers (not shown) so that the object becomes exactly centred between those fingers and can subsequently be gripped by them without forcing the object laterally: an important consideration in some applications.

When the object has been centred as described above, the controller 9 causes a linear actuator 23 to raise a plate 25 carrying an abutment 26 which slides in a groove 27. The groove 27 is arranged at an angle so that this motion causes the whole plate 4 and the components mounted on it to pivot about an axis 38. This action is produced simultaneously on all the fingers thereby causing them to grip the object securely.

In an alternative form of the invention it would be possible for the controller 10, on detection of the peak at range D1 to adjust the gain of the amplifier 21 to give the peak a pre-set value Y as indicated on Figure 2 irrespective of the coefficient of reflectivity of the object 2. During subsequent movement of the finger towards the object, i.e. from range D1 to 0, the relationship between the output of the amplifier 21 and range will follow a known curve as shown at C on Figure 2 and so the controller 10 can calculate the exact range D at any time.

CLAIMS

1. Apparatus comprising an optical sensor having a transmitter and a receiver which are spaced from each other and arranged so that transmitted light is returned to the receiver after reflection from an object to be sensed with an intensity which depends on the range of the object and is at a peak at a particular range; characterised by a peak detector arranged to receive the output of the receiver and to perform a control function when the output reaches the said peak.

2. Apparatus according to claim 1 comprising drive means for changing the distance between the optical detector and the said object; and a distance measuring means for measuring the said distance change; and in which the said control function includes commencing such measurement in response to detection of the aforementioned peak.

3. Apparatus according to claim 1 or 2 including a manipulator adapted to be driven by the drive means towards an object to be manipulated; and in which the control function includes changing the mode of operation of the drive means.

4. Apparatus according to claim 3 when dependent on claim 2 adapted to change the mode of operation of the drive means after the said distance has changed by specified measured amounts.

5. Apparatus according to claim 3 or 4 in which the change in the mode of operation is between a fast initial movement towards the object and a slow gripping movement to hold the object.

6. Apparatus substantially as described with reference to the accompanying drawings.

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